to verification—is still in development at a few academic centers. The "mini" MLC can be added to any accelerator, indeed can even be retrofit to a cobalt treatment machine. It is about 1/4 the price of the standard device. The mini-MLC system has been commercialized and is in clinical use at approximately 20 centers in the United States. Since only a portion of the treatment can be delivered at any one time, however, the treatment may take as long as 30 minutes instead of the 5–10 minutes of "beam on" time. Also, exact registration of the slices (the step-wise movement of the patient inward with respect to the treatment beam after each rotation) is critical to avoid overdose or underdose where the slices abut.

Early clinical results have been published for head and neck cancers, for CNS malignancy, and for prostate cancer. Doses in the range of 8600 cGy have been achieved for prostate cancer without increased acute rectal and bladder toxicity, compared with conventional treatment to doses of 6600–7000 cGy. Patients with central aerodigestive-tract malignancy and involved neck nodes have been locally controlled with less xerostomia due to the ability to spare the salivary glands from significant radiation dose. Tumors wrapped around the optic nerve or spinal cord have been treated with therapeutic doses without any degradation of vision or motor function. The Radiation Therapy Oncology Group is currently planning a phase III trial of this modality vs. conventional treatment. Subsequent to this trial the radiation oncology community may anticipate that technology transfer could occur rapidly, so that the approach will become available to benefit appropriately selected patients with potentially curable local tumors.

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The Future of Teleradiology in Medicine

TELERADIOLOGY ALLOWS THE VIEWING of diagnostic imaging studies at a site remote from the imaging location and has historically been used for on-call coverage, particularly of CT and ultrasound. Now, technology and the forces of medicine have combined to develop two new possibilities. One potentially enables any clinician to review, at any location, imaging studies (and reports) of patients under his or her care. The other allows imaging specialists to perform remote primary interpretation.

Initially, most teleradiology systems were quite crude and slow, and often captured image data with only moderate resolution and accuracy. Today, these systems are increasingly connected or integrated to a Picture Archiving and Communication System (PACS), using the Digital Imaging Communication in Medicine (DICOM) standard of the American College of Radiology.

Currently, a combination of increased computing power, including high speed and abundant memory at very reasonable cost, enables the remote display of a more accurate and detailed representation of the original image. Display technology has also improved to the degree that these systems have the capability to view conventional radiographs, in addition to CT, ultrasound, and MR, provided the images are captured at appropriate resolution. Communication technology allows movement of images at greater speed via fast modems, ISDN, and dedicated communication links inside and outside of hospitals. In addition, advances in the area of image compression allow the packing of image data more tightly, which further enhances transmission speed. Compression methods known as *wavelets* appear to allow high compression with no perceptible loss of diagnostic information.

Security for teleradiology is an area that is being addressed, partly in response to new government regulations for patient privacy protection. Teleradiology systems are being used increasingly for remote interpretation, particularly for CT and MR, raising issues of credentialing, licensing, and traditional relationships between referring clinicians and local radiologists. Image transmission and the viewing process are somewhat slower than a dedicated in-hospital PACS, unless similar workstations are used. Projection radiology, i.e. bone and chest, is technically more challenging.

Most recently the World Wide Web has provided exciting new software solutions to the problem of moving image data. It is in use today at many academic centers. Clinicians can expect to have access to patients' images at any location once this technology is more widely available. Ideally, advanced teleradiology will enable improved diagnostic imaging for underserved populations.

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New Methods of Treatment for Cerebral Aneurysms

THERE IS NOW almost a decade of accumulated clinical experience with the Guglielmi Detachable Coil (GDC) in the treatment of cerebral aneurysms. This represents a major new option in the "minimally invasive treatment" methods now available to patients with cerebrovascular disease and stroke. The basic GDC design consists of a helical platinum coil attached to a stainless steel delivery wire. Under x-ray guidance, the soft platinum coil is positioned within the aneurysm lumen via a microcatheter navigated to the aneurysm neck. Once a satisfactory configuration is attained, the coil is detached from the delivery wire by electrolysis. The objective is to pack the aneurysm with a sufficient number of coils to induce endosaccular thrombosis and occlusion, thus preventing arterial inflow. This technique obviates the need for a surgical craniotomy. Approximately 27,000 patients have undergone this treatment.

The most satisfying technical results are seen in smaller aneurysms (<12-mm diameter) with narrow necks. Wide-necked aneurysms remain technically challenging because of the proclivity of coil loops to cross the broad neck and herniate into the parent arterial lumen. Fusiform aneurysms also remain a challenge because occlusion of the aneurysm lumen usually results in simultaneous blockage of the parent artery.

In addition to factors related to aneurysm morphology, the feasibility of endovascular aneurysm treatment also relates to the aneurysm site. Middle cerebral artery aneurysms are usually more difficult to treat because of more complex anatomical arrangements encountered in this location. For treatment of posterior circulation aneurysms, however, endovascular techniques may offer advantages over surgical clipping because of difficult surgical access and the risk of injury to small arterial perforator vessels and neural structures. Other potential advantages of the endovascular route over surgery are that brain retraction is avoided (especially relevant in acute aneurysms where the brain may be swollen and edematous), and the ability to stage procedures in medically compromised patients with large or complex acute aneurysms.

A longer-term problem associated with the use of GDC is the phenomenon of coil compaction. Over time the endosaccular coil conglomerate may compact, resulting in partial recanalization of the aneurysm, usually at the neck. For this reason, follow-up angiography is necessary. The likelihood of coil compaction may correlate to the density and completeness of the original coil pack, the size of the aneurysm and aneurysm neck, the presence of aneurysm thrombus, and the position of the aneurysm. End-artery locations such as terminal carotid or basilar tip aneurysms may be prone to coil compaction because the direction of the arterial inflow vector is perpendicular to the aneurysm neck, producing a so- called water-hammer effect against the coils.

The largest published series examining the efficacy of the GDC system in treatment of acute subarachnoid hemorrhage is a North American multi-center prospective trial in which 403 patients were enrolled. All of these patients were excluded from aneurysm surgery because of technical difficulty, poor medical condition, or other reasons and therefore represent a high-risk group. The proportion of posterior circulation aneurysms within this cohort was 57%. The overall reported rates of morbidity and mortality were 9% and 6% respectively. These figures compare favorably with the natural history of untreated ruptured aneurysms. The data suggest that GDC embolization in subarachnoid hemorrhage may be less effective in giant aneurysms (>2.5-cm. diameter) and may not improve clinical outcomes in those patients with pre-existent poor clinical status. A European multicenter prospective randomized controlled trial comparing surgery to endovascular treatment of ruptured aneurysms is currently in progress. Rebleeding rates following endovascular coiling remain to be defined. The preliminary data are encouraging, however, indicating an overall rebleeding rate of 0.5% or less per annum. A recent prospective study of clinical outcomes (average of 3.5 years follow-up) found 86% of 61 patients treated with GDC for acute subarachnoid hemorrhage had an excellent or good outcome.

Valid comparisons of morbidity and mortality with surgical clipping in acute subarachnoid hemorrhage, particularly with respect to anterior cerebral circulation aneurysms (and especially anterior communicating artery aneurysms which overall are the most common) are difficult to make using the current data. The results of prospective randomized controlled trials are awaited. Endovascular technology, however, continues to evolve rapidly, as does clinical expertise with these techniques, forecasting further improvement in healing aneurysms using the endovascular route.

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Extracranial Carotid Stenosis: Ultrasound, MRI, Angiography

IN EXPERIENCED HANDS, with proper instrumentation, vascular ultrasound is the screening study of choice for extracranial carotid artery disease because it is accurate, non-invasive, and the least costly of the three main options. This technique uses bilateral morphologic images to assess the extent of plaque and tortuosity, and to determine whether there is a high carotid bifurcation.

Another essential component is an evaluation of flow dynamics using color Doppler, and spectral analysis in the internal carotid artery, the external carotid artery, the vertebral artery, and the proximal, mid, and distal portions of the common carotid artery.

To assure quality of operator and instrumentation, the sonogram should be done in an accredited laboratory under the supervision of an experienced registered vascular technologist. Laboratory accreditation is obtained through either the Intersociety Commission for the Accreditation of Vascular Laboratories or the American College of Radiology Vascular Ultrasound Accreditation Program.